E-Clouds / TMCI : MD Goals and Results, Data Analysis and Simulations, Feedback Models and System Implications

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Electron Cloud / TMCI Project - CM18

- CM 16 Report:
  - Progress in macro-particles simulation codes: Real Feedback Models - Statical errors.
  - MD preparation: Simulations - Estimations.
  - Further analysis of MD data - E-clouds - Measurements (y-displ.)
  - Integration of those results to modeling and identification.
- CM 17 Report:
  - Preliminary Results of Summer MDs at SPS
- CM 18 Report:
  - MDs: Goals.
  - Hardware installed.
  - MD Results .
  - Simulation - Modeling.

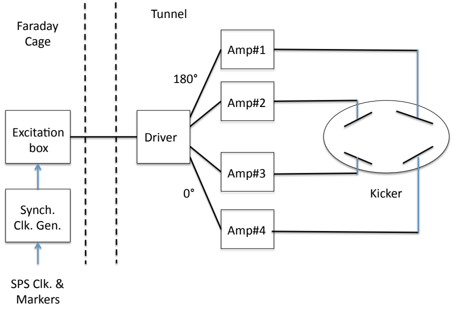
MD Goals - Results

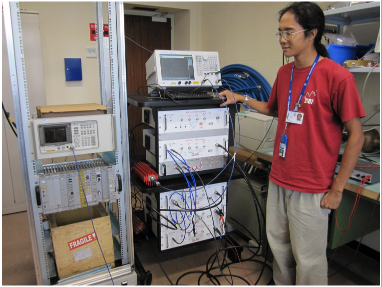
MD Goals

- Install Hardware in the SPS tunnel/Faraday cage and be able to drive the beam (Single Bunch)
- Test the system to drive as many bunch modes as possible
- Evaluate a method to time properly the kicker signal with the bunch.
- Estimate the momentum kick for different frequencies across the bunch.
- Test appropriated signal to be able to identify the bunch dynamics,
- Analyze options to transform the present hardware / software in a beam-machine diagnostic tool.

MD Goals - Results

MD Hardware

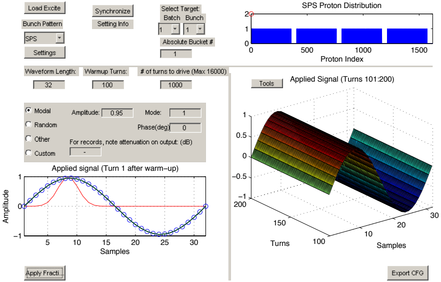


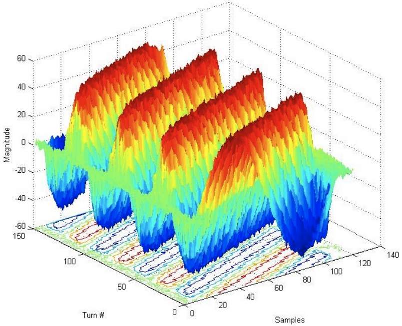


MD Goals - Results

Excitation System - Main Features

- Synchronize excitation signal with a selected bunch in the machine.
- 3.2 - 4GS/s programable unit that allows generating arbitrary signals in time (turns) and across the bunch (z-axis).
- Allows driving the bunch with an arbitrary kick signal.
- Able to follow at some level the bunch during acceleration.

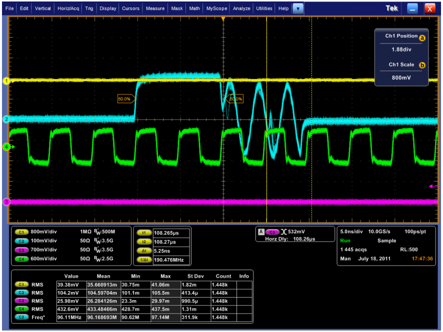




MD Goals - Results

Excitation System - Signal Examples

- Synchronize excitation signal with selected with selected bunch in the machine.
- 3.4-4GS/s programable unit that allow generate arbitrary signals time (turns) and across the bunch (z-axis).



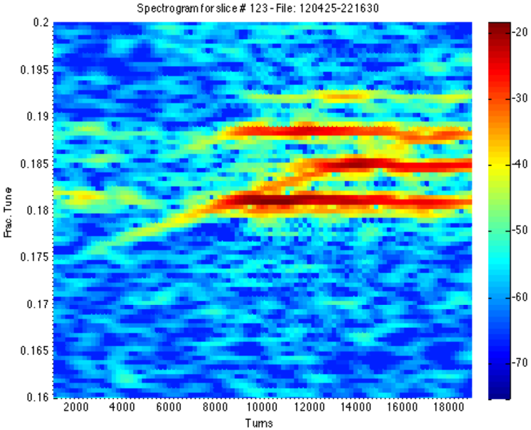
MD Goals - Results

MD Results - Bunch multimode motions

- We drove the beam using a composite AM signal that drives head-tail motion across the bunch.
  - $M(z, t_0) = Asin(\frac{2\pi}{T_b}z)f(t_0), \qquad z \in [0\, T_b),\, T_b = 5ns.$
- Along the turns we swept the fractional frequency $FracFreq(t)$ of the signal 0.175 to 0.185 in 15K turns
  - $M(z, t) = Asin(\frac{2\pi}{T_b}z)sin(\theta(t)) \qquad \theta(t) = 2\pi \int FracFreq(t)dt$
- The frac. betatron tune of the machine was $f_\beta = 0.181$, the frac. synchrotron tune was $f_S \simeq 0.004$
- The equalized SIGMA and DELTA (dipole) signals for 20K turns are ...(movies)

MD Goals - Results

MD Results - Bunch multimode motions

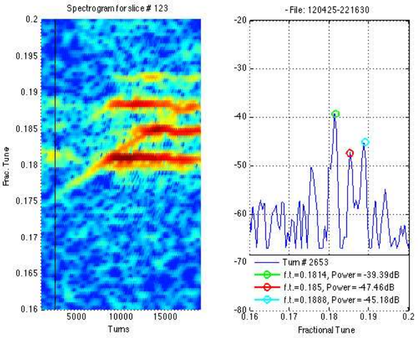


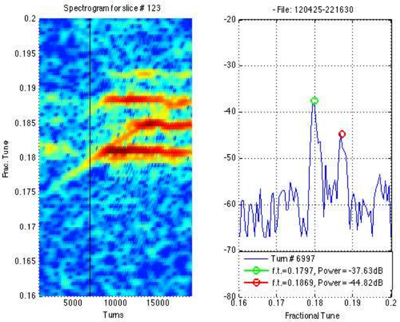
- Spectrum slice 123 - Delta SIGNAL.

MD Goals - Results

MD Results - Bunch multimode motions

- Spectrum slice 123 - Turns 2653 and 6997 .

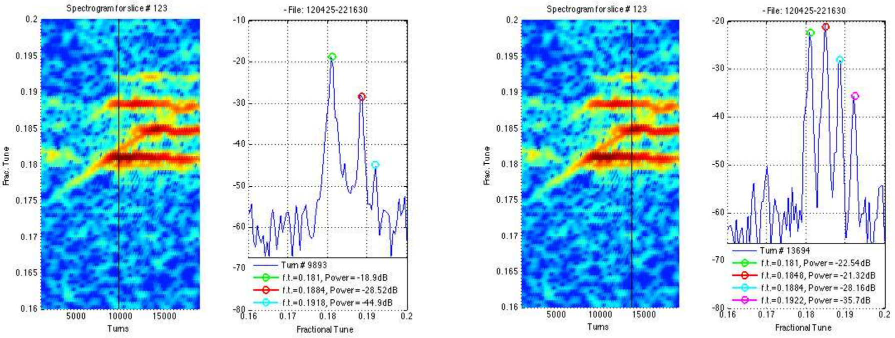




MD Goals - Results

MD Results - Bunch multimode motions

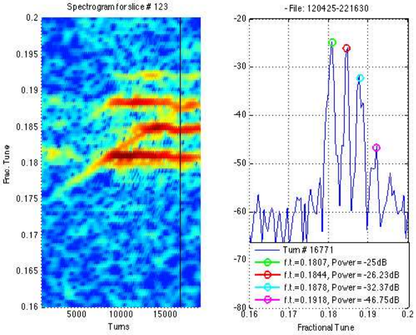
- Spectrum slice 123 - Turns 9893 and 13694 .



MD Goals - Results

MD Results - Bunch multimode motions

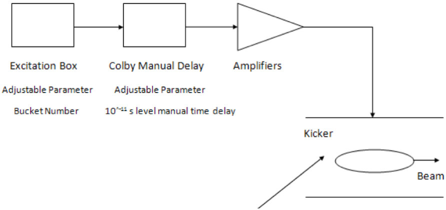
- Spectrum slice 123 - Turns 16771 and 18762.

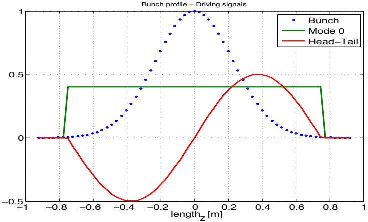


MD Goals - Results

Kicker Signal - Bunch Timming

- An important outcome of these studies is the design of a technique to time the kicker signal relative to the bunch position.
- It is important to drive efficiently the bunch and it will be crucial for next the step related to the feedback control of intra-bunch motions.
- Excitation system has two time adjustments: Coarse:5ns steps, Fine:10ps.
- Tests of the timing technique were conducted using different signals

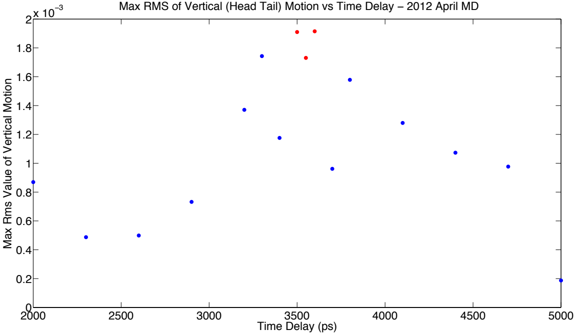




MD Goals - Results

Kicker Signal - Bunch Timing

- Preliminary results of timing study based on head-tail motion of the bunch
- RMS of the bunch vertical motion for different delays

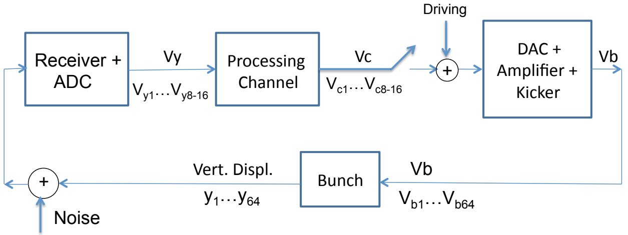


MD Goals - Results

Other tests

- Using different signals, we tried to drive different vertical modes of the bunch motion
- In particular we used signals at constant frequency to study the kicker strength
- We drove the beam with 'filtered random' signals to test possible identification techniques to characterize the bunch dynamics.
- Direct these studies (driving the beam with particular signals) to define techniques to parameterize the beam dynamics and to measure the machine impedance.

Macro - Particle Simulation - Modeling



- Realistic feedback channels have been in CMAD, Head-Tail, Warp simulation codes.
- We are testing the effect of the kicker bandwidth in the bunch stabilization due E-clouds.
- Studies to define the kicker+amplifier power have shown that low-levels are required to stabilize the beam dynamics due to E-cloud interaction.

Conclusions

Conclusions - Further plans

- We conducted three MDs, driving the proton bunch..
- Test different ways of driving the bunch and developing analysis techniques to measure kicker strength, and bunch dynamics.
- Special attention to techniques to time the kicker signal respect to the bunch, in order to progress toward next step: Feedback channel to demonstrate intrabunch control and stabilization.
- Introduced realistic models for the feedback system in macro-particle simulation codes (C-MAD, WARP, HT Head-tail) We are in the process of validating the simulations code to represent the bunch instabilities induced by E-clouds and Transverse Mode Coupling.
- Defining identification techniques to extract reduced dynamical model of the proton bunch - Extend to techniques based on periodic excitation signals. Use data from the MDs

Thanks to the audience for your attention!!!, ...Questions?